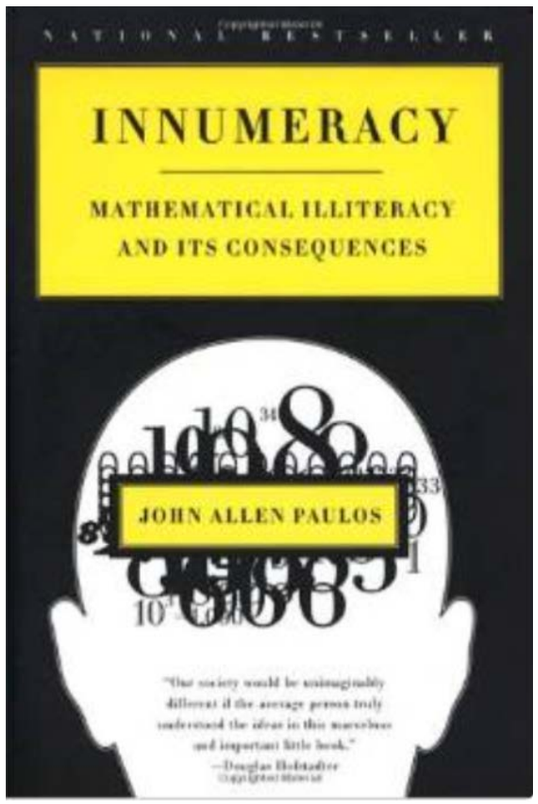
Adventures in Public Outreach for Space Physics: Some Recent Experiences

Message matching the audience, without predisposition to “Science for science’s sake”

Phil Erickson
MIT Haystack Observatory

CEDAR 2017 Workshop
Education and Public Policy
Keystone, CO 2017-06-20

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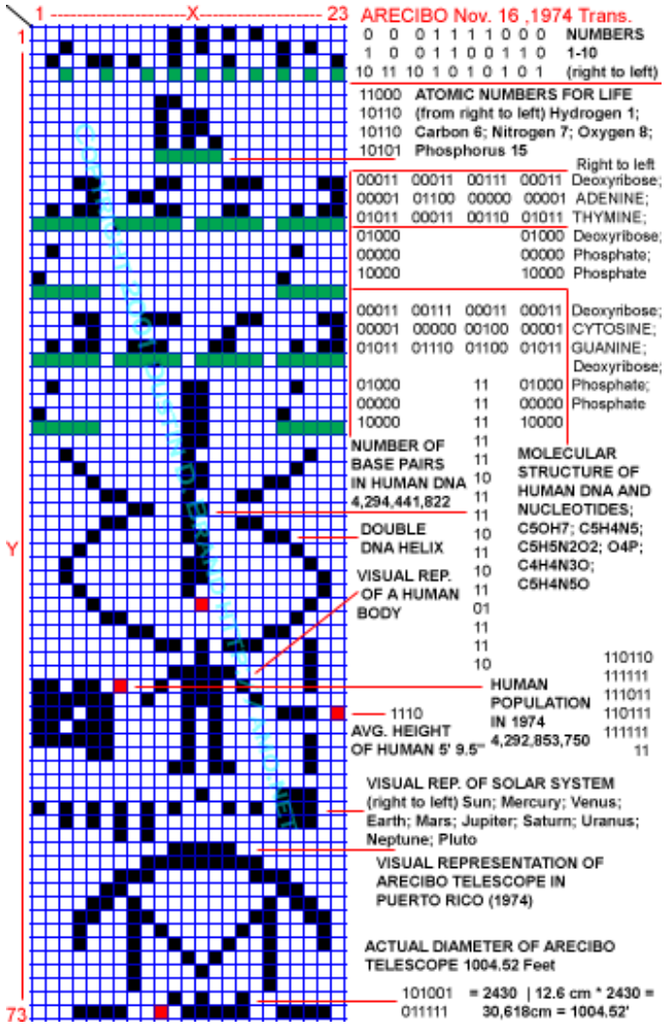
Why People Believe Conspiracy Theories

Why people who believe in one conspiracy are prone to believe others

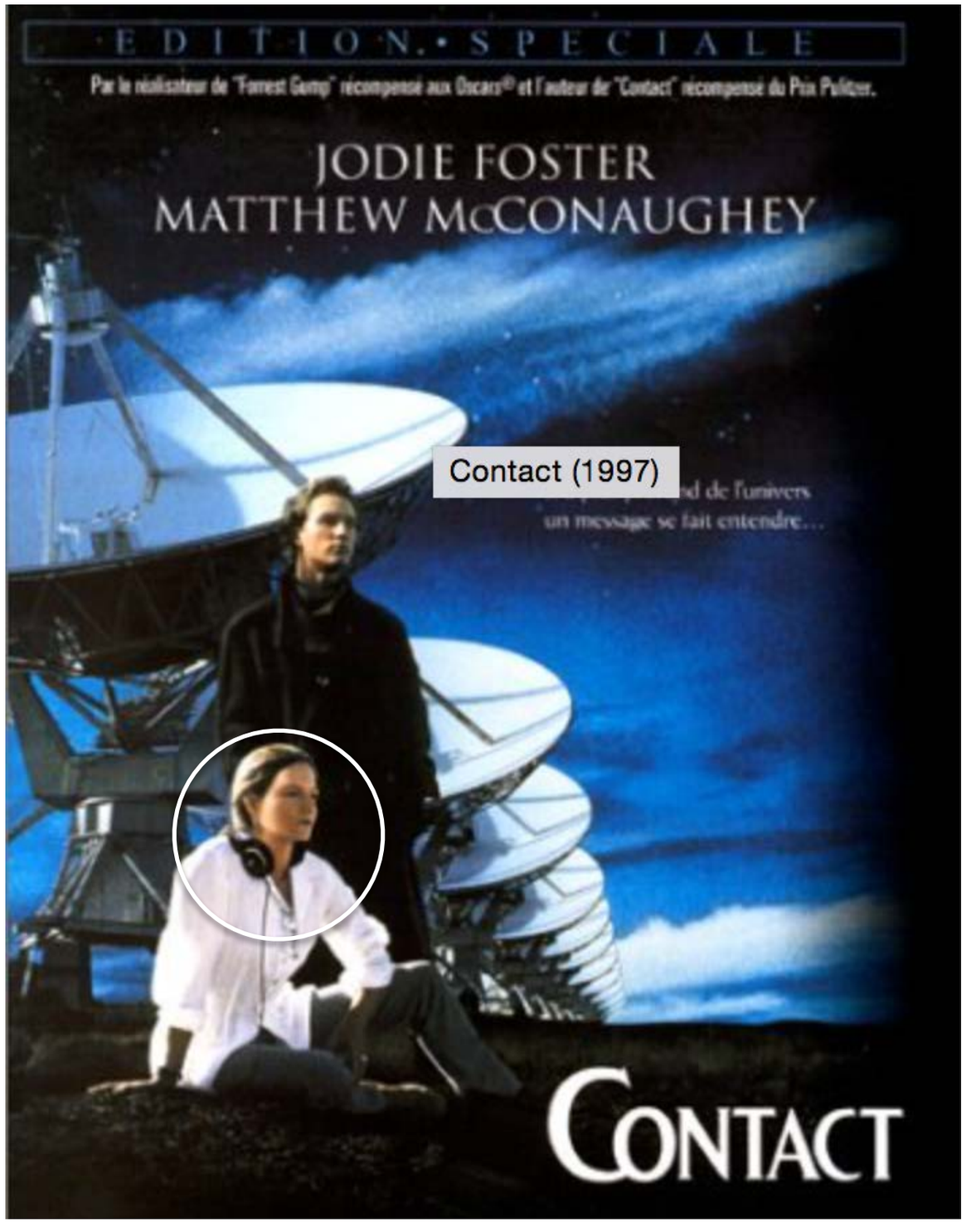
By Michael Shermer | Aug 15, 2012

Topic 1: The truth is necessary but it can be more boring.

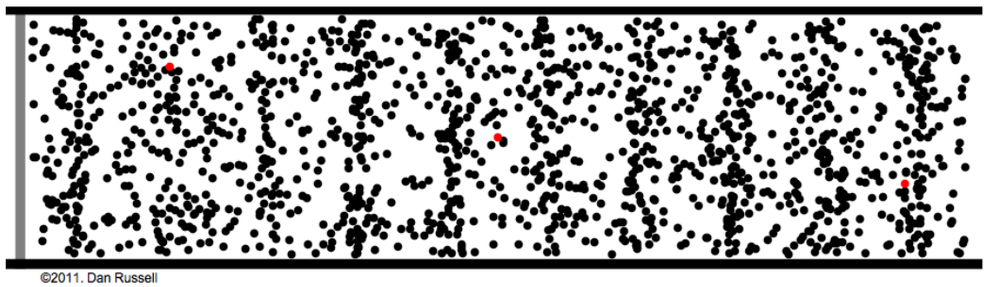
Arecibo Observatory
established 1964
primary design goal: ionospheric radar

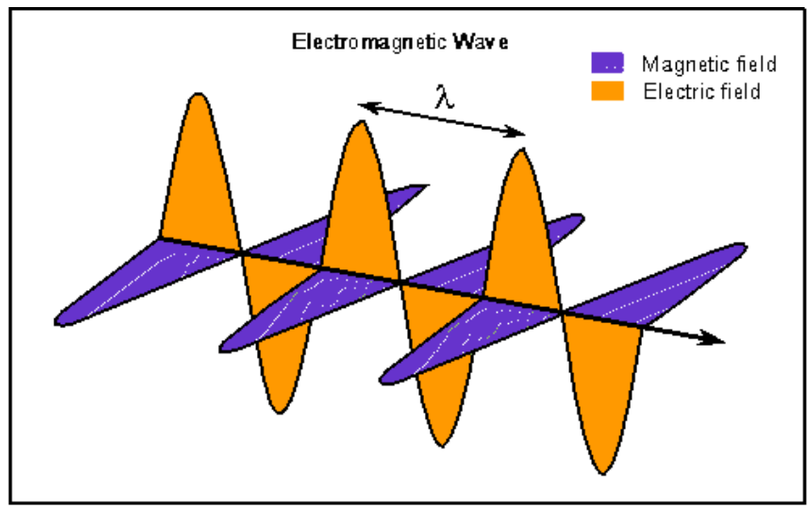


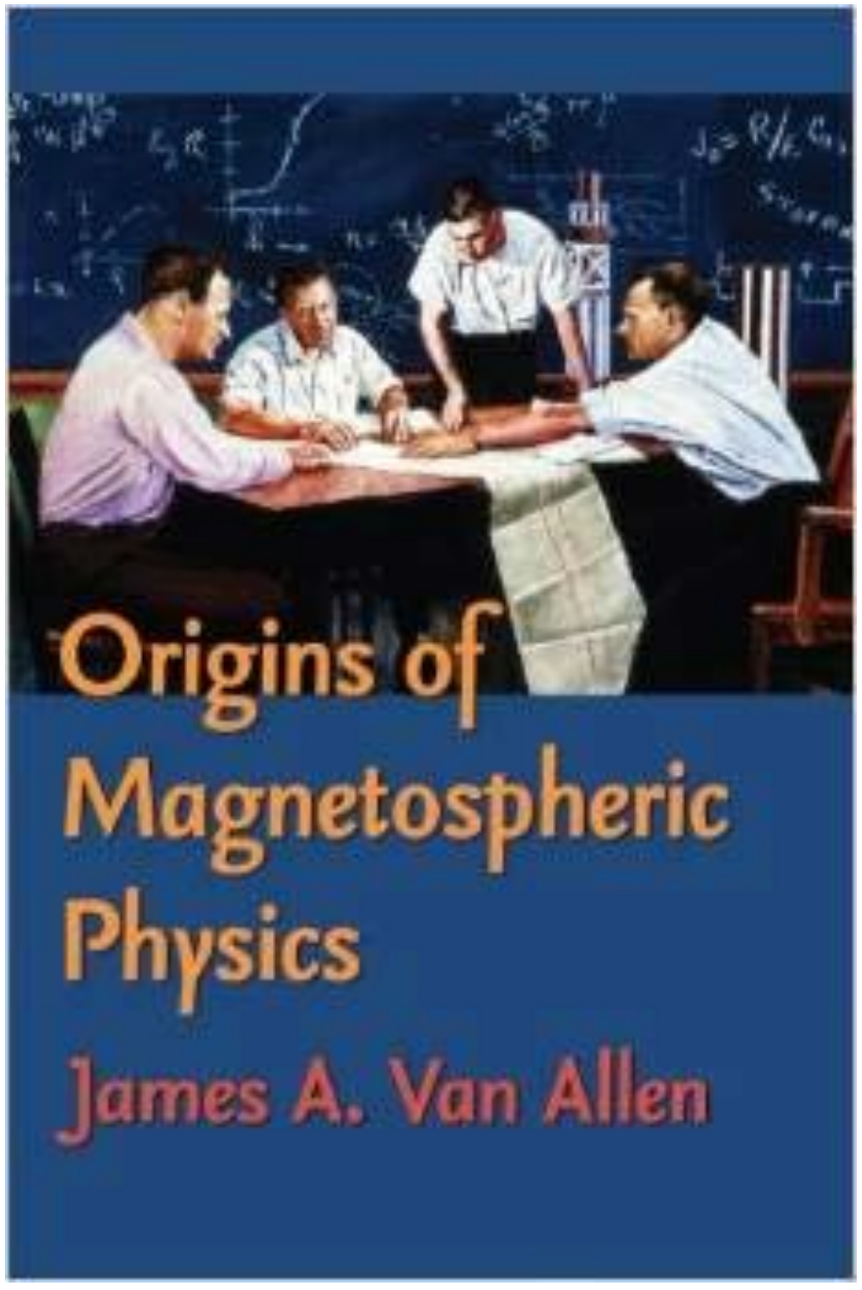
The challenges of public outreach: Reality vs. Hollywood



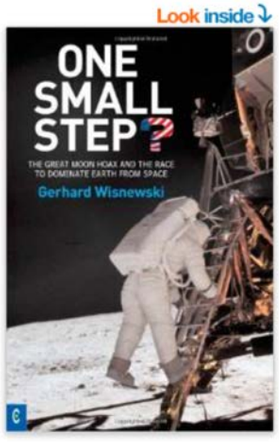
Contact (1997)







"… space is radioactive" - Ernie Ray



One Small Step? : The Great Moon Hoax and the Race to Dominate Earth from Space Paperback – January 15, 2008

by Gerhard Wisnewski (Author)

26 customer reviews

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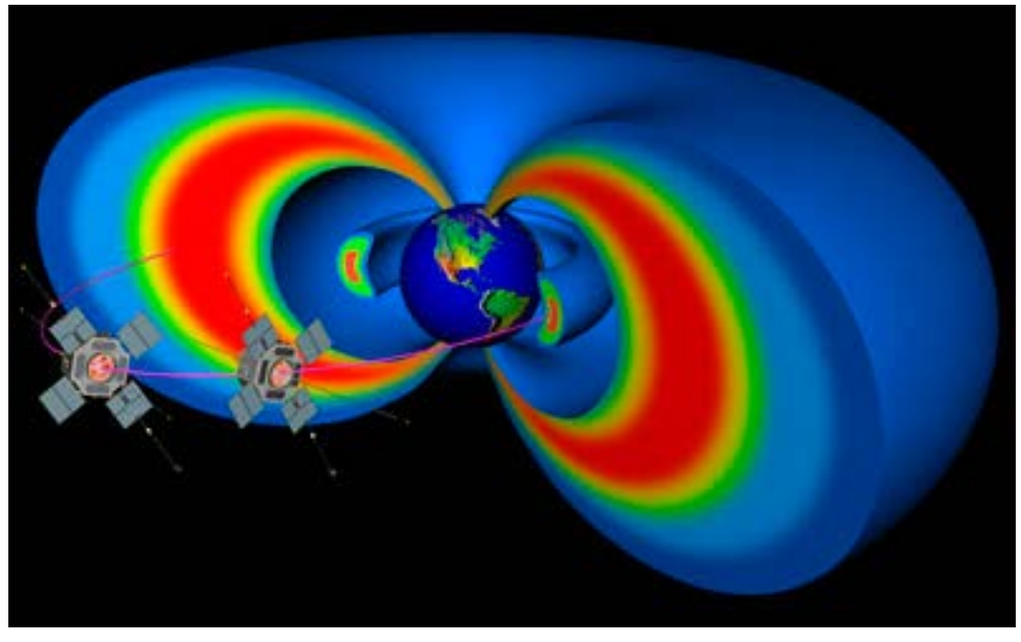
Were the famous moon landings simulated by NASA? From the very first manned flight into orbit right up to the present day there have been serious anomalies in the official narrative of the conquest of space. Bestselling author Gerhard Wisnewski dissects the history of space travel in minute detail, beginning with the first Russian missions in the early 1960s, to the final American moon project of Apollo 17 in 1972, and onwards to the



JOURNAL OF GEOPHYSICAL RESEARCH VOLUME 64, NO. 11 NOVEMBER, 1959

The Geomagnetically Trapped Corpuscular Radiation

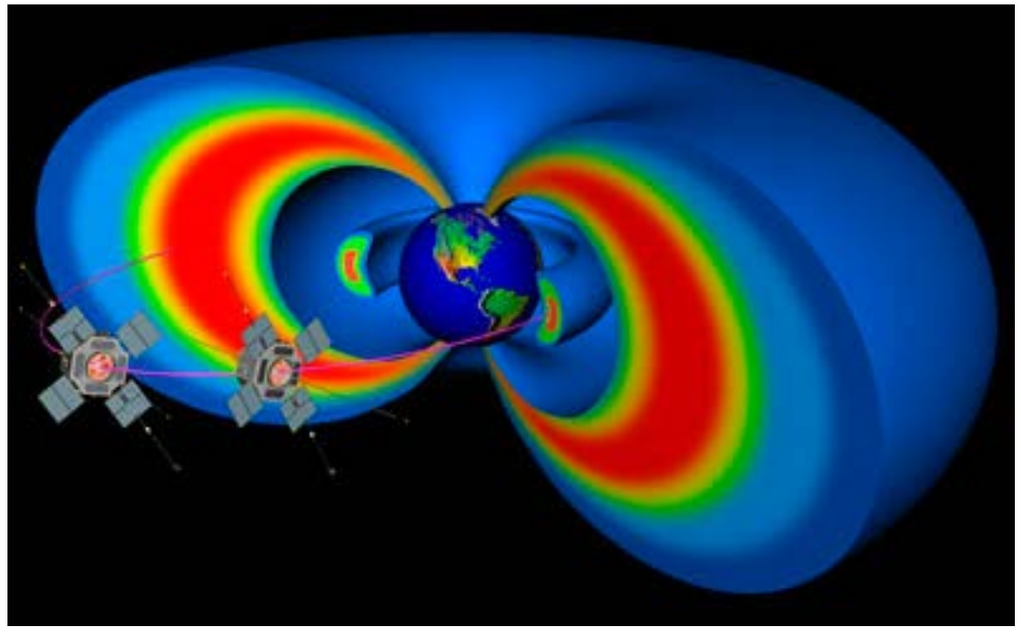
JAMES A. VAN ALLEN

State University of Iowa
Iowa City, Iowa

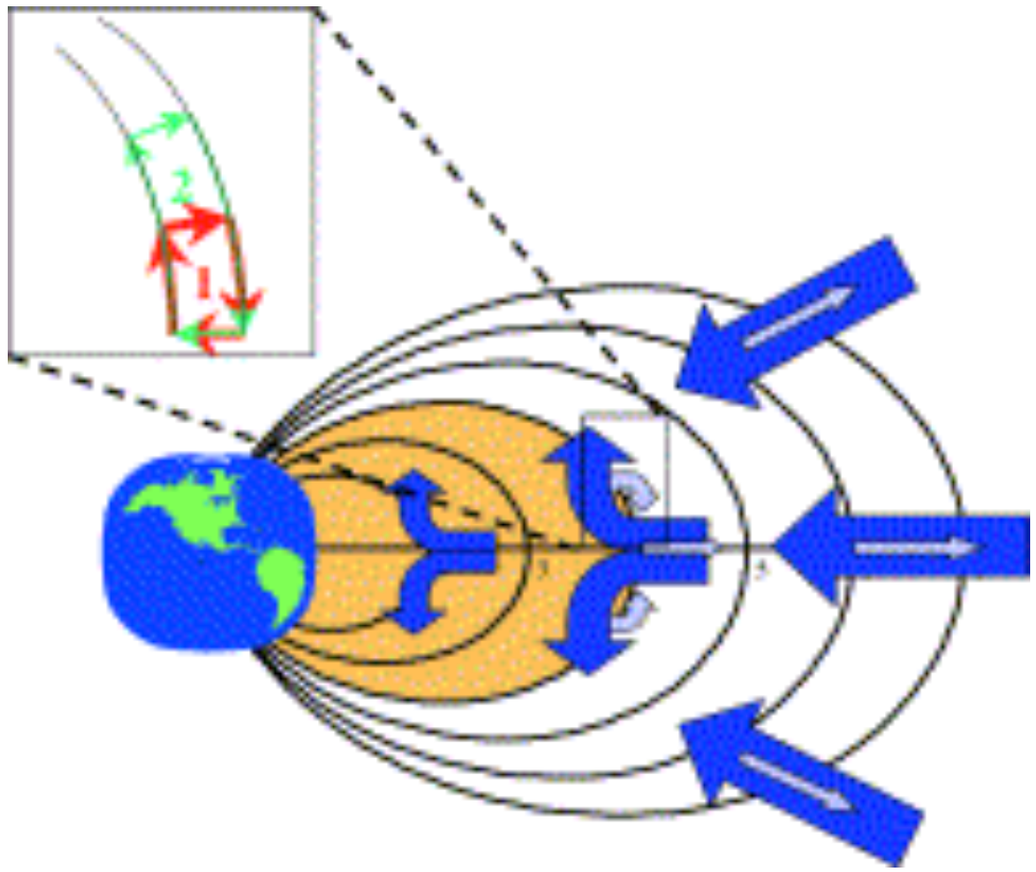
From “space is radioactive” -

A Numerate Question:

Is the aurora due to radiation belt precipitation?
And if it is, are humans altering it?



Operation Argus
1958
(let's make an artificial radiation belt and see if it's tactically useful.)



Friedel et al 2002
Cross-field diffusion

Very slow depending on energy
(many hours to days to weeks/months)

Conclusion:
Aurora and magnetosphere radiation belts
are both driven directly by solar wind energy input

(see 2015 Student workshop talk for details.)

Topic 3: We're all mad scientists.

P(TX) = 1E6 W

G = 42 dB ~ 2E4

MIT Haystack Observatory
Westford, MA

Millstone Hill UHF Radar

G = 42 dB ~ 2E4

P(TX) = 1E6 W

Will MIT Haystack
boil the upper atmosphere
by transmitting this much power??

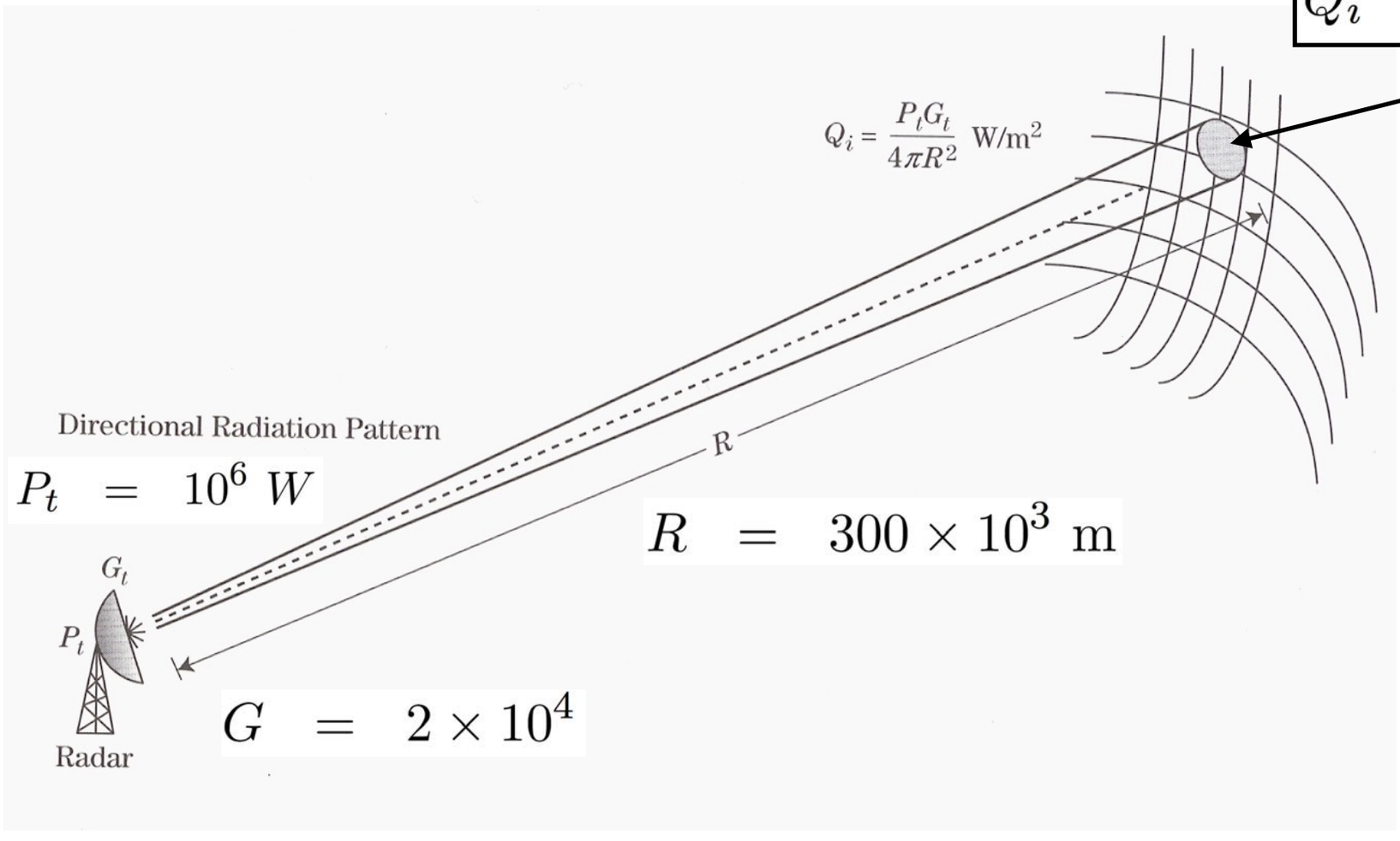
(Actual asked question.)

MIT Haystack Observatory
Westford, MA

Millstone Hill UHF Radar

The Radar Equation: Monostatic Version

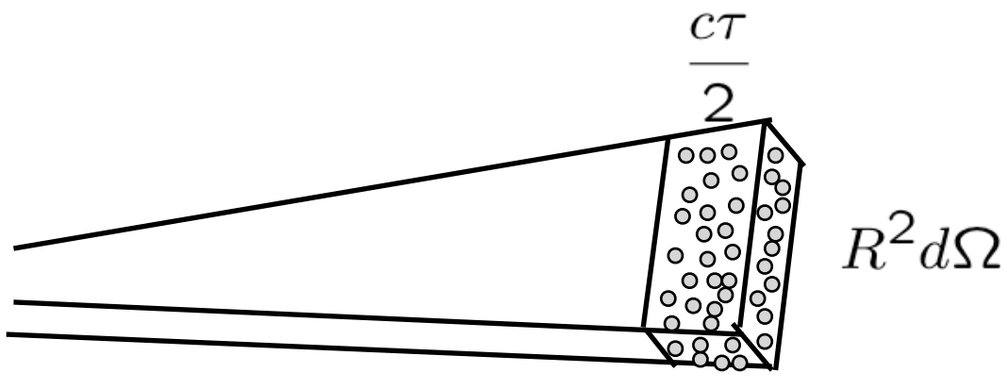
Power density at range R (directional): $\dfrac{P_t\ G}{4\pi R^2}$



Radar Cross-section of the Ionosphere: Distributed Target

$$\int \sigma(\vec{x})\ dV_s = \int_0^{2\pi} \int_0^{\pi} \sigma(\vec{x})\ \frac{c\tau}{2}\ R^2 d\Omega$$

$$\int \sigma(\vec{x})\ dV_s = \frac{c\tau}{2} \int_0^{2\pi} \int_0^{\pi} \sigma(\vec{x})\ R^2 \sin\theta\ d\theta\ d\phi$$



Assume volume is filled with identical, isotropic scatters

$$\int \sigma(\vec{x})\ dV_s = \frac{c\tau}{2} R^2 \sigma$$

Single Electron Scattering Model

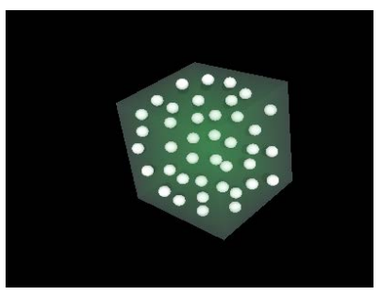
Incident EM wave accelerates each charged particle it encounters.
These then re-radiate an EM wave (as Hertzian dipoles).

For a single electron located at r = 0, the scattered field at a distance r_s:

scattered field $\left|\vec{E}_s(\vec{r}_s,t)\right| = \dfrac{e^2\mu_0 \sin\delta}{4\pi r_s m_e}\left|\vec{E}_i(0,t')\right|$ Incident field

$$= \frac{r_e}{r_s}\sin\delta\left|\vec{E}_i(0,t')\right|$$

8.85×10^{-15} m $\boxed{r_e = \dfrac{e^2\mu_0}{4\pi m_e}}$ Classical electron radius



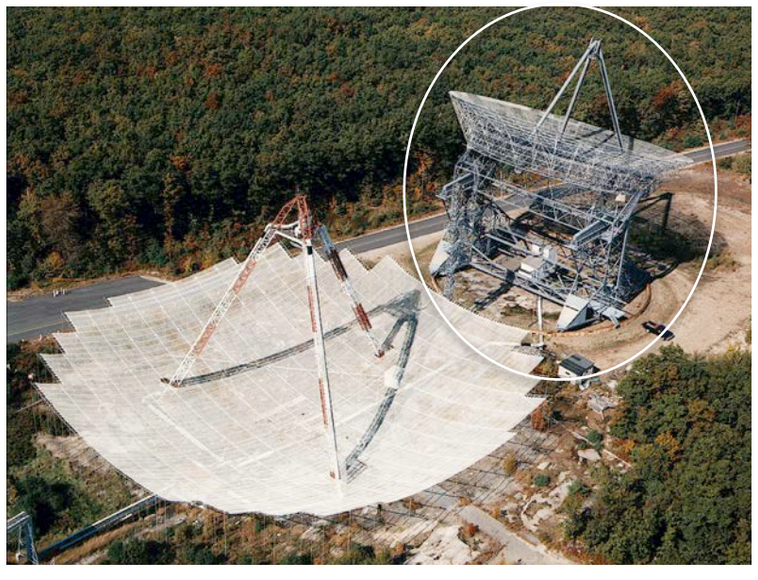
Radar cross-section of ionospheric plasma

Assume a beam filling plasma at F region altitudes (300 km) with very high electron density (1E12 electrons per m3 - BEST CASE):

Classical electron scattering cross-section $\sigma_e = 10^{-28} m^2/e^-$

Assume an along-beam pulse length of 10 km (67 usec in time).
Assume a cross-beam width of 6.2 km (~ Millstone Hill antenna with FWHM = 1.2 deg).

Total cross section is then (10 km x 6.2 km x 6.2 km x 1E12 m^-3 x 1E-28 m^-2/e-):



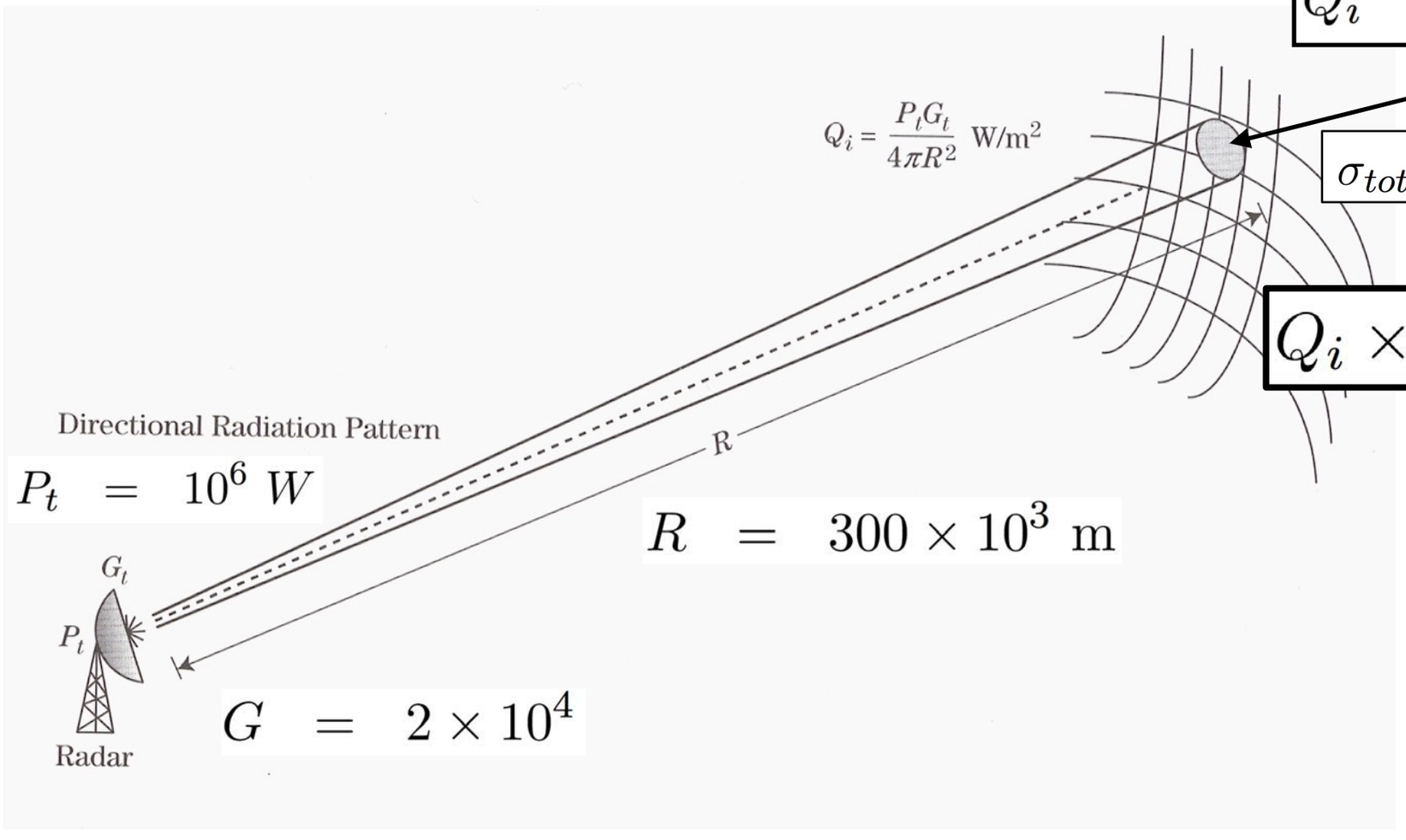
$$\sigma_{tot} \sim 3.8 \times 10^{-5}\ \mathrm{m}^2$$

The Radar Equation: Monostatic Version

Power density at range R (directional):

$$\frac{P_t\ G}{4\pi R^2}$$

$$Q_i \quad = \quad 8.84\ \mathrm{mW/m^2}$$



Energy Flow From Sun To Earth

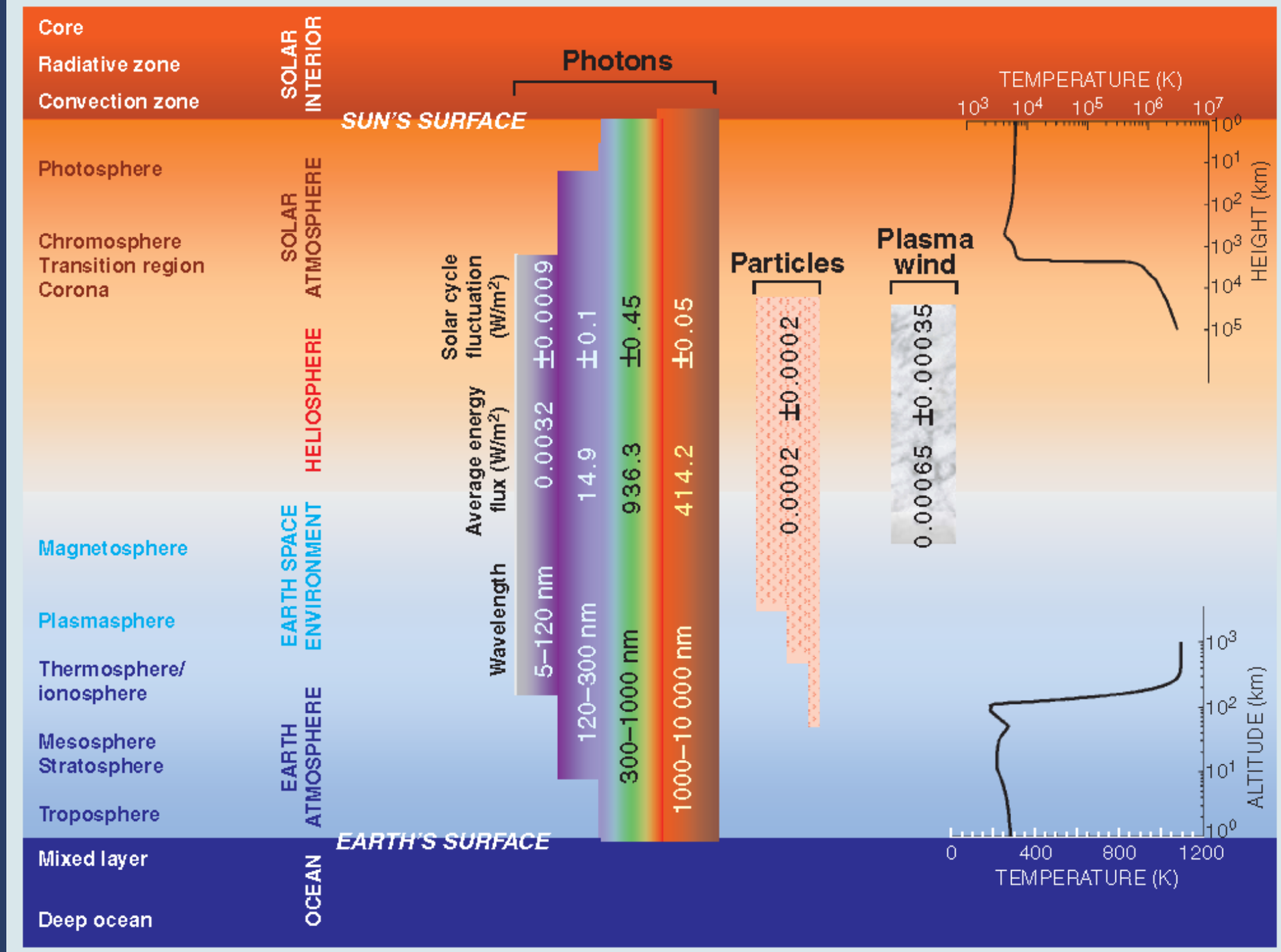
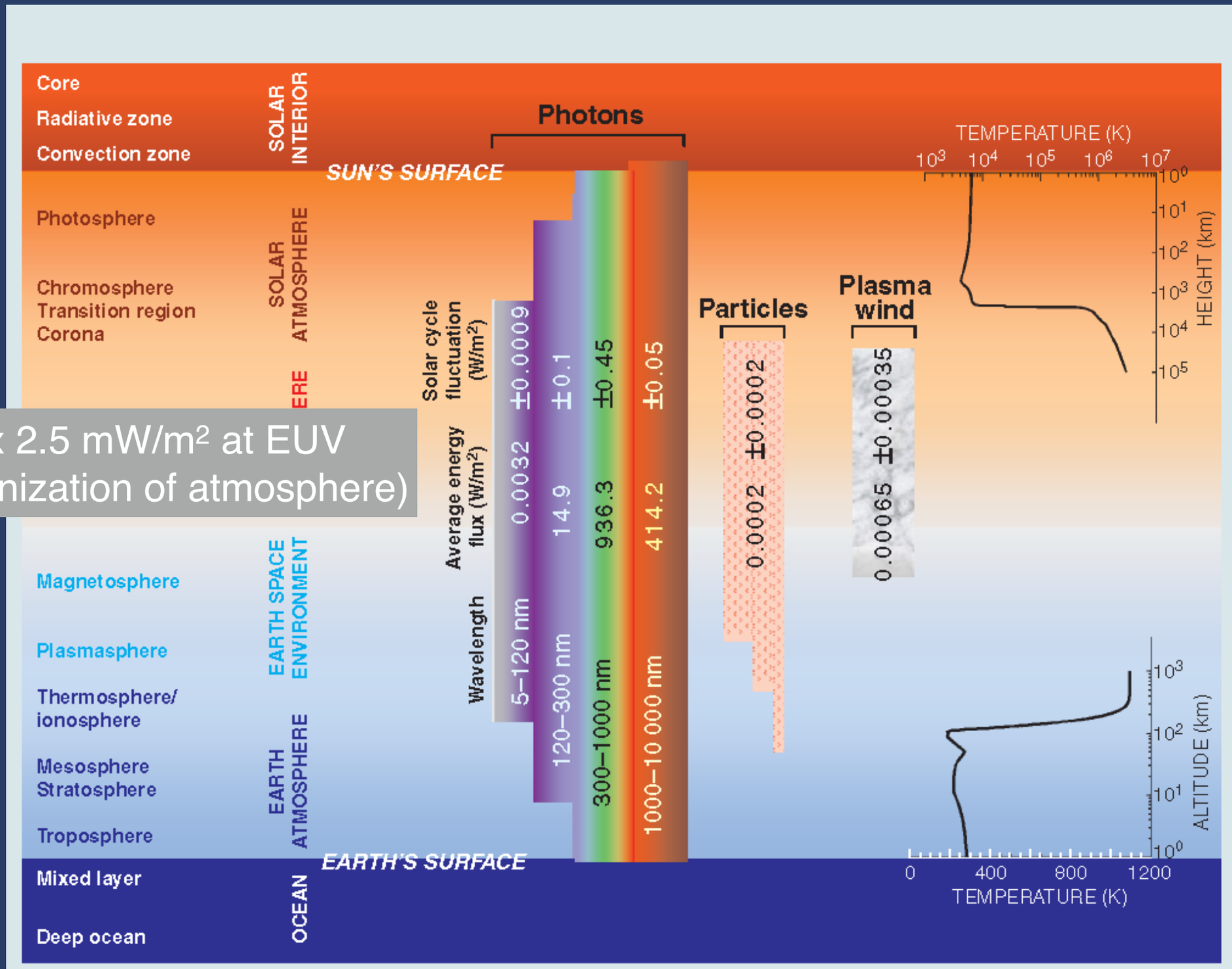


Figure 2. The energy flow from the Sun to Earth roughly maps corresponding regions of the respective atmospheres. Visible radiation connects the surfaces of the Sun and Earth; UV radiation connects their atmospheres. Particles and the plasma wind connect the outer solar atmosphere primarily with Earth's magnetosphere and high-latitude upper atmosphere. For photons in four different wavelength bands, energetic particles, and the plasma wind, the numbers give the approximate average energy fluxes and variations during an 11-year solar activity cycle. On the right are approximate temperature profiles of the solar and Earth atmospheres.

Energy Flow From Sun To Earth



Approx 2.5 mW/m² at EUV (causes ionization of atmosphere)

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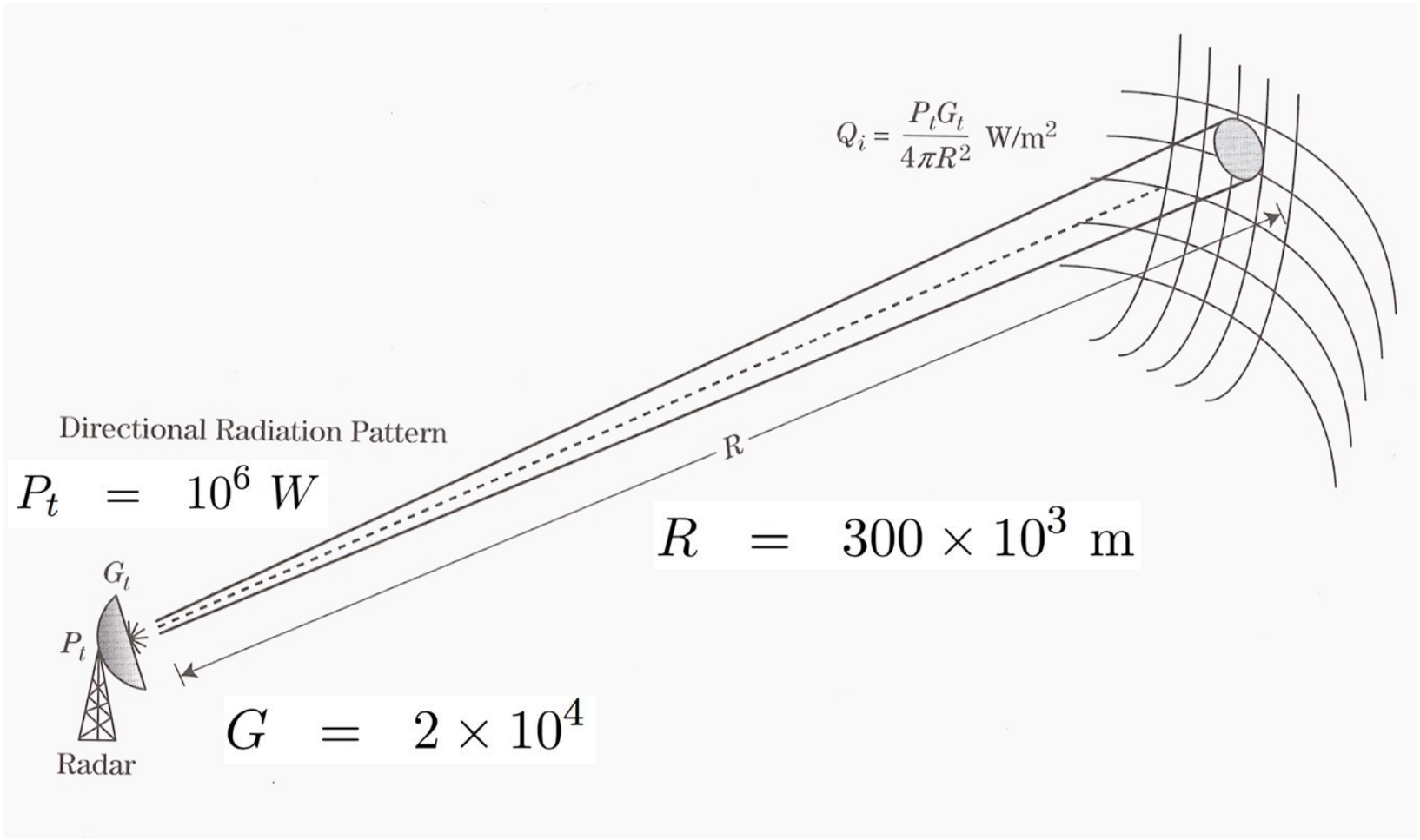
The Radar Equation: Monostatic Version

Millstone Hill radar (with 6% duty cycle):

$$0.06 * Q_i \times \sigma_{tot} = 1.9 \times 10^{-5} \text{ W}$$

EUV solar input over the same illuminated volume:

$$2.5 \times 10^{-3} \text{ W/m}^2 \times (6.2 \times 10^3 \text{ m})^2 = 9.6 \times 10^4 \text{ W}$$



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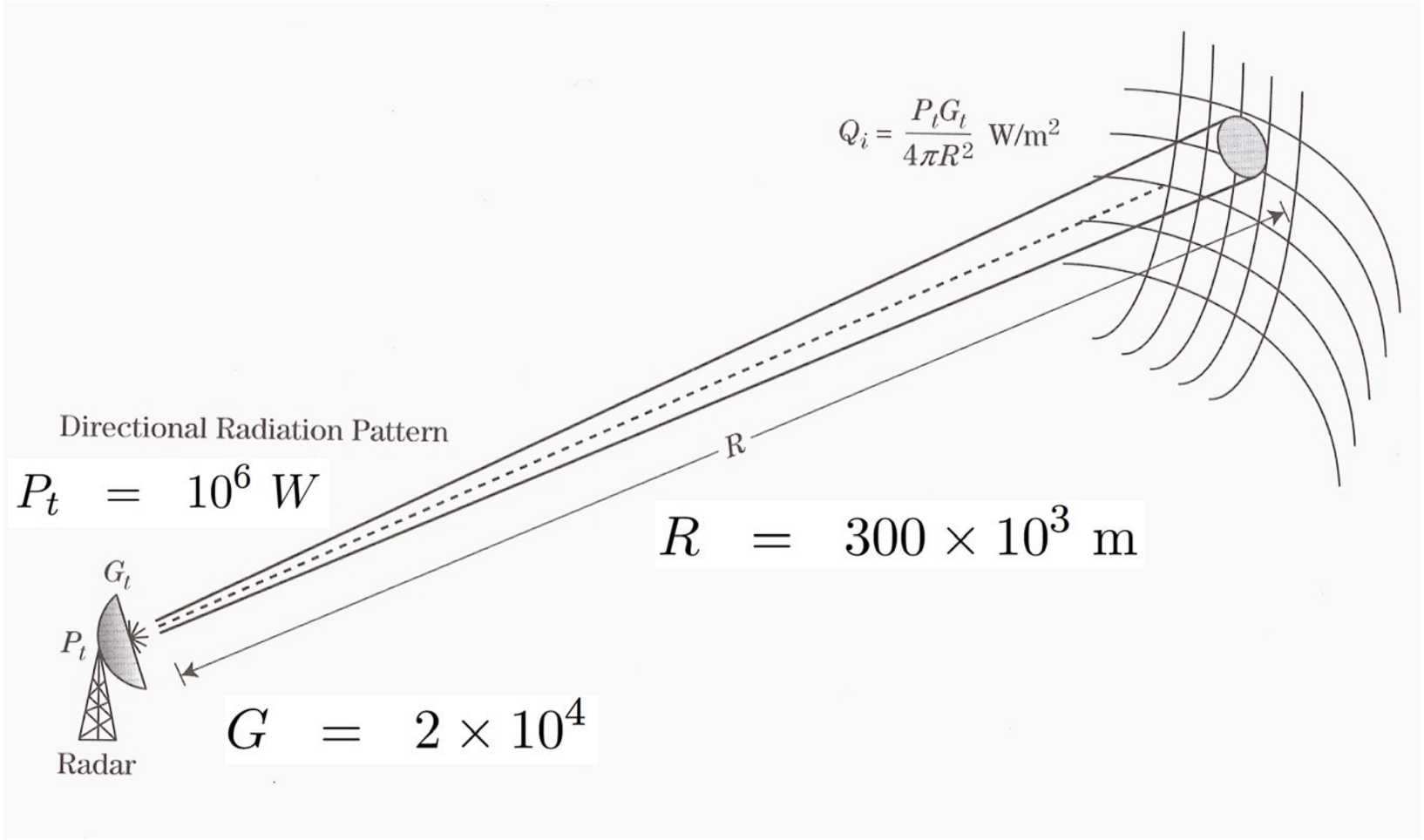
Ratio ~ 2E-8 percent.

Millstone Hill will not boil the atmosphere by doing IS radar experiments.

We are not utterly mad scientists.

(A considerable relief to me.)



Topic 4: You never know what is going to catch the public attention. (So be prepared.)

Space Science Reviews
pp 1–55

Anthropogenic Space Weather

Authors Authors and affiliations

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Article

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Part of the following topical collections:

- The Scientific Foundation of Space Weather

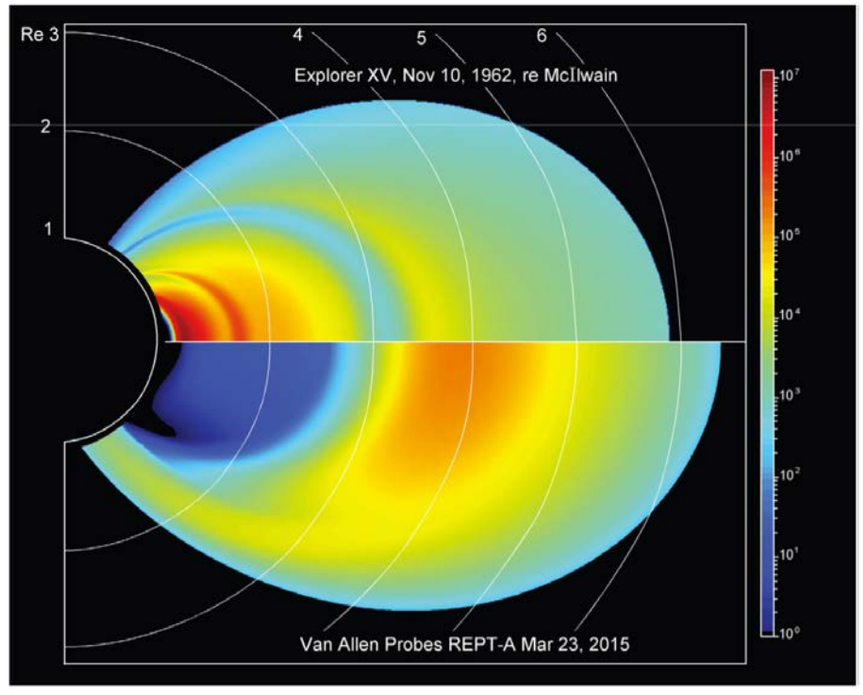
Topic 4: You never know what is going to catch the public attention. (So be prepared.)

Keywords

High-altitude nuclear explosions | Artificial radiation belts | Electromagnetic pulse (EMP) | Damage to satellites | Space Debris | Chemical releases | HF heating | VLF waves and radiation belts

Fig. 1 From *left to right*, the Orange, Teak, Kingfish, Checkmate, and Starfish high-altitude nuclear tests conducted in 1958 and 1962 by the United States near Johnston Island in the mid-Pacific (from Foster et al. 2008)

Fig. 7 Samples of E1 HEMP exposed regions for several burst heights. The *red circles* show the exposed regions for the given burst heights, for a nuclear burst over the central US (from Savage et al. 2010)



Topic 4: You never know what is going to catch the public attention. (So be prepared.)

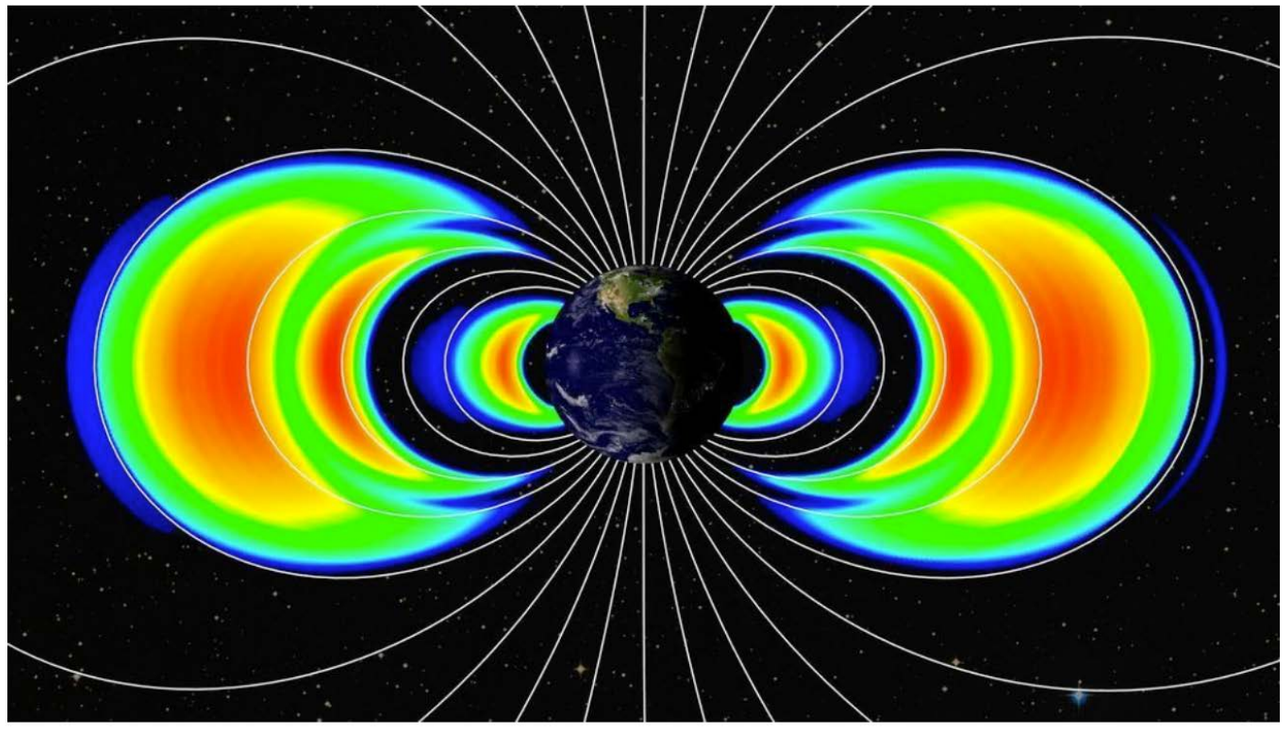
GSFC press release

Space

We may have accidentally formed a protective bubble around Earth

Radio waves might help protect us from space weather.

By *Sarah Fecht* *May 19, 2017*



Stray radio waves may push part of the Van Allen radiation belts away from Earth, which is good news for our satellites; the high-energy particles trapped in the belts can destroy a spacecraft's electrical equipment.

JHUAPL/LASP

7.6 Turn Equipment off

There is truth to this recommendation (if there were a way to know that a burst was about to happen). Equipment is more vulnerable if it is operating, because some failure modes involving HEMP E1 phase trigger the system's energy to damage itself. However, damage can also happen, but not as easily, to systems that are turned off.

8 Space Weather Effects of Anthropogenic VLF Transmissions

8.1 Brief History of VLF Transmitters

By the end of World War 1, the United States military began use of very low frequency radio transmissions (VLF; 3–30 kHz) for long-distance shore to surface ship communications

Topic 1: The truth can be boring but it's the truth.

Topic 2: Inject numeracy in Public Discussions (but carefully).

Topic 3: Assert that scientists do practice ethical science.

Topic 4: You never know what is going to catch the public attention. (So be prepared.)